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ABSTRACT

This study attempted tc replicate and extend previous aptitude-treatment interaction (ATI) findings for students' learning in large-group and small-group teaching approaches. Two elementary teachers each taught a twc-week geometry unit to two classes of fourth- and fifth-grade students. One teacher used a small-group teaching approach and the other used a large-grcup approach. A stratified random assignment approach was then used to ensure that within each class students were either matched or mismatched on their initial preferences for the teaching approach. Students were also stratified according to ability. At the beginning of the study students completed aptitude measures and at the end they completed achievement, attitude, and retention measures. In addition, each class was observed by a pair of observers during the course of the study. Results indicated that matching teaching approach to students' initial preferences did not affect students' achievement, retention, or attitude scores but did affect their classroom behavior. Regression analyses supported previous ATI findings in that a significant curvilinear ATI for ability was found in the present study. High and low ability students did better in the small-group approach than in the large-grcup approach while medium ability students did slightly better in the large-group approach than in the small-group approach. (Author/MP)

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INDIVIDUAL CHARACTERISTICS AND CHILDREN'S LEARNING IN LARGE-GROUP AND SMALL-GROUP APPROACHES: STUDY II

by

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Report from the Project on
Studies of Instructional Programming for the Individual Student

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Abstract

This study attempted to replicate and extend previous aptitude-treatment interaction (ATI) findings for students' learning in large-group and small-group teaching approaches. Each of two elementary teachers taught a 2-week geometry unit to two classes of fourth- and fifth-grade students. Each class received one teaching approach. Stratified random assignment was used, so within each class students were either matched or mismatched on their initial preferences for the teaching approach. Students completed aptitude measures at the beginning of the study and achievement, attitude, and retention measures at the end. Results indicated that matching teaching approach to students' initial preferences did not affect students' achievement, retention, or attitude scores but did affect their classroom behavior. Regression analyses showed significant curvilinear ATI for ability that supported previous ATI findings. High and low ability students did better in the small-group approach than in the large-group approach. Medium ability students did slightly better in the large-group approach than in the small-group approach.

The purpose of the present study was to replicate and extend the findings of an aptitude-treatment interaction study by Peterson and Janicki (1979) of children's learning in a large-group approach in which each child worked alone and in a small-group approach in which each child worked with other children in a mixed-ability group. Peterson and Janicki found that neither the large-group approach nor the small-group approach was more effective for all students. Some types of students did better on a delayed test in the large-group approach, while other types of students did better in the small-group approach. Students who, before the study, said they preferred learning in a small-group approach actually did worse on the delayed test in that approach and better in the large-group approach. On the other hand, students who said they preferred a large-group approach actually did worse in that approach and better in the small-group approach. In addition, high ability students did better on the delayed test in the small-group approach, and low ability students did better on the delayed test in the large-group approach.

Peterson and Janicki (1979) compared their aptitude-treatment interaction (ATI) findings for ability to that of Webb (Note 1). Both studies found a significant ability x treatment interaction for students' performance on the delayed test. However, Webb found a curvilinear ATI for ability. High ability students did equally well after learning individually or in small mixed-ability groups; medium ability students did better after learning individually; and low ability students did better after learning in small mixed-ability groups. In the Peterson and Janicki study,

the ability x treatment interaction was a linear one. High ability students did better after learning in the small-group approach than after learning individually in the large-group approach, while low ability students did better after learning individually in the large-group approach than after learning in the small-group approach.

Peterson and Janicki noted two important differences between the two studies that may have accounted for the diverse results. First, students in the Webb (Note 1) study were high school students, and students in the Peterson and Janicki (1979) study were fourth-, fifth-, and sixth-grade students. Second, the "large-group" approach in the Peterson and Janicki study may not have corresponded to the "individual" treatment in the Webb study. In the individual treatment, students worked alone without direction or assistance. In the large-group approach students worked alone but were given direction and assistance by the teacher as needed.

Despite differences between the two studies, Peterson and Janicki found that the group process variables noted by Webb helped explain the ATI for ability in their study. Peterson and Janicki found that high ability students often explained to other students in their small group. These explanations usually consisted of helping another student with a workbook problem or "teaching" the other student how to work a certain kind of problem. Apparently, these explanations benefited the giver of the explanation but did not necessarily help the receiver. Thus, high ability students learned much about fractions by explaining the material to other students in their small group.

The present study used the aptitude measures and the treatments from the Peterson and Janicki (1979) study in an attempt to replicate and

extend the ATI findings from that study.[1] Specifically, we expected to obtain a significant ATI for ability as in the Webb (Note 1) and Peterson and Janicki (1979) studies. Furthermore, we expected that observations of group processes would be useful in explaining the ATI for ability. In addition, we wanted to investigate further the finding that students actually did worse in the approach that they had initially preferred. Because many educators have argued that students will do best if they are assigned to an approach that matches their own stated preference (see, for example, Dunn & Dunn, 1978), we wanted to test the Peterson and Janicki finding that matching the teaching approach to the student's own preference may have deleterious effects on students' performance. In the Peterson and Janicki study, the ATI finding for group preference was a correlational one--students were randomly assigned to classes so that within each class they varied on their preference for learning approach. In the present study, we wanted to test the effect of matching or mismatching the teaching approach to the students' own preference. Thus, students were assigned to classes so that within each class students were either matched or mismatched to the teaching approach that was to be used in that class.

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[1] In this study "aptitude" refers to "any characteristic of a person that forecasts his probability of success under a given treatment" (Cronbach & Snow, 1977, p. 6).

Method

Subjects

Ninety-three male and female students from the fourth/fifth-grade unit of an elementary school in rural Wisconsin participated in the study. Students were assigned to one of four classes taught by one of two experienced female teachers selected to take part in the study. The teacher participants were chosen from among four volunteers. All the teachers received honorariums for their participation in the study.

Instrumentation

At the beginning of the study, students completed the following aptitude measures: the Mathematics Basic Concepts (Form 4a) subtest from the Sequential Tests of Educational Progress (STEP) (Cronbach's alpha (α) = .87); Raven's Progressive Matrices (Raven, 1958) (α = .92); the Academic Achievement Accountability Questionnaire (AAA) (α = .79) by Clifford (1976); an attitude toward math scale (α = .89); a preference for learning in small groups scale (α = .66) ;and a "learn best" scale asking students in what approach they would do their best work (α = .71).

The 18-item AAA scale, a measure of locus of control, was scored so that a high score represented an internal locus of control and a low score indicated an external locus of control. The attitude toward math scale consisted of 15 items developed by Peterson and Janicki (1979) and adapted from the Science Attitude Inventory developed by Klausmeier, DiLuzio, and Brumet (Note 2). The scale had a 5-point response format with the following response alternatives: "strongly agree," "agree," "don't care," "disagree," and "strongly disagree."

The preference for learning in small groups scale consisted of eight items developed by Peterson and Janicki (1979). This questionnaire was adapted from the "What kind of class?" scale developed by Solomon and Kendall (Note 3). To each of the scale's eight items, the student was requested to respond with one of two alternatives, each of which represented an instructional procedure characteristic of a small- or large-group learning approach; for example, "I would most like a math class where (a) the teacher gives kids any help they need;" or (b) "Kids spend a lot of time helping each other." Higher scores on this scale indicated a preference for learning in a small group. The "learn best" scale consisted of the same items as the preference for learning approach scale except the stem of each item was changed to, "I would do my best work in a math class where ..." This scale was developed to assess whether students would respond differently when asked what kind of class they would do their best work in than when asked what kind of class they would most like.

At the completion of the 2-week unit on geometry, student achievement was assessed using a 39-item experimenter-constructed test (α = .82) designed to measure comprehension and application of the major concepts taught in the unit. The same test was administered 2 weeks later to assess retention (α = .84). Students also completed the same attitude toward math scale which was administered at the beginning of the study (α = .87) and an attitude toward learning approach scale (α = .73). The eight-item attitude toward learning approach scale was developed by Peterson and Janicki (1979). It consisted of questions such as "I wish we could have math class this way all the time." Students responded along

a 5-point Likert scale from "strongly agree" to "strongly disagree."

Classroom observations were conducted to assess fidelity of implementation of the two instructional approaches and to describe group processes. Using an adaptation of the observation instrument developed by Peterson and Janicki (1979), coders checked the categories of behavior engaged in by each member of a small group of three to four students during 18 consecutive 20-second intervals. The observation order was counterbalanced so that each group was observed at different times during the class period during the study. Teacher behavior and the behavior of class members at large were also coded for each of the intervals.

The generalizability of the observations was assessed using the procedure described by Cronbach, Gleser, Nanda, and Rajaratnam (1972). An estimate of the generalizability of the observations across coders and days was obtained by having two pairs of coders code each teacher teaching each approach on 3 days. Day was considered to be a fixed effect. The categories for individual students and their generalizability coefficients (ρ) averaged over the two pairs of coders were as follows: student explains to another student during seatwork (ρ = .58); student receives an explanation from another student during seatwork (ρ = .61); student is waiting for help during seatwork (ρ = .96); and student is off-task during seatwork (ρ = .88). The categories and generalizability coefficients for teacher and class behaviors were: teacher reviews (ρ = .73), teacher lectures (ρ = .44); teacher asks question (ρ = .97); teacher employs controlled practice (ρ = .91); class works in small groups (ρ = .99); class works individually (ρ = .99); and teacher actively monitors student seatwork (ρ = .82).

Procedure

Several weeks before the study began, the experimenter met with the teachers to discuss the teaching approaches and curriculum. At this time the experimenter described the two approaches and how they should be implemented in the classroom. The experimenter provided the teachers with the following guidelines: In both the large and small groups it was suggested that the teachers spend parts of each class period (a) reviewing the major points of preceding lessons and/or discussing particularly troublesome concepts, and (b) introducing new material by explaining it to the class as a whole group, asking questions of the class, assigning short problems for the students to work, and working problems on the board. The experimenter recommended that the students spend approximately half of each class period working on workbook assignments. Seatwork for the large-group approach was to proceed as follows: Students would work on the assignment by themselves. The teacher would monitor the work of individual students and provide help as needed. In the small-group approach, students would write answers in their own workbooks, but should consult with other students in the group in arriving at the answers. Students should get help from others in the group before asking the teacher for assistance. The teacher would monitor the work of small groups but should provide help only when none of the students in the group could work the problem or answer the questions raised.

The curriculum unit for the study consisted of the geometry unit from Developing Mathematical Processes (Wisconsin Research and Development Center for Cognitive Learning, 1976). During the preparatory work sessions, the teachers were provided with the curriculum materials which

constituted the basis of the unit--a teacher guidebook and a student guidebook and workbook. Using the detailed lesson activities contained in the guidebook along with the experimenter's instructions as to which of the guidebook activities should be incorporated into the actual curriculum unit, the teachers developed two sets of lesson plans--one for each teaching approach. This was to insure that exactly the same content was covered in all classes and that the two teachers taught each approach in the same way.

Two weeks before the study began, the students completed the aptitude tests. On the basis of their responses on these measures, students were assigned to treatment groups.

In two classes, one taught using a large-group approach and the other, a small-group approach, students were assigned so that their stated preference for learning in a large or small group matched the approach employed in the class. Students were mismatched on preference for learning approach in the other two classes. Assignment of students to classes was done by performing a median split on students' scores on the preference for learning approach scale. Within each of the resulting two groups students were then stratified on ability using a bivariate distribution of their scores on the math concepts subtest of the Sequential Tests of Educational Progress and their scores on Raven's Progressive Matrices. Stratified random assignment was carried out such that an equivalent number of high, medium, and low ability students who were above the median on preference--preferred a small-group approach--were assigned to either a small-group approach (matched on preference) or a large-group approach (mismatched on preference). Similarly, an equivalent number of

high, medium, and low ability students who were below the median on preference--preferred a large-group approach--were assigned to either a small-group approach (mismatched on preference) or a large-group approach (matched on preference). Within each of the two classes taught with the small-group approach, groups of four students were formed such that each small group contained one high, two medium, and one low ability student. Each teacher taught two classes--one using a small-group approach and the other a large-group approach. The resulting class sizes were small group/matched, 24, small group/mismatched, 24, large group/mismatched, 22, and large group/matched, 23.

During the study, each teacher taught the geometry unit for 40 minutes per day according to the approach to which the class had been randomly assigned. In order to accommodate the school's regular schedule, the study was designed so that teacher 1 taught the mismatched/small group for 9 days while teacher 2 taught the matched/large group. During the subsequent 9 days, teacher 1 taught the mismatched/large group while teacher 2 taught the matched/small group.

Each class of the two pairs of classes was coded by one observer on each of the days during the study and by a second reliability observer during 3 days of each week. Each pair of observers coded the class of one teacher for 1 week and the class of the other teacher during the 2nd week of instruction. After 9 days of instruction, the students completed the geometry achievement test, the attitude toward teaching approach scale, and the attitude toward mathematics scale. Two weeks after the posttest date, the achievement test was readministered.

Generalizability analyses on the observation instrument were done with BMD: Biomedical Computer Program (Dixon, 1971). All other statistical analyses were performed with SPSS: Statistical Package for the Social Sciences (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975).

Results

Fidelity of Implementation of Teaching Approaches

Table 1 presents the means and standard deviations in minutes per day for each observation category in the four classes. These means indicate that the teaching approaches did differ as intended. In the two classes using the small-group approach, students worked on seatwork in small groups for 16.87 and 15.11 minutes, respectively, and did not work individually on seatwork. In the two classes using the large-group approach, students worked individually on seatwork for 13.85 minutes and 11.68 minutes, respectively, and did not work in small groups on seatwork.

However, the means in Table 1 also indicate that within the small-group approach the two teachers differed in their implementation on at least two behaviors. First, teacher 1 in the small-group approach spent an average of only 2.06 minutes per day in reviewing while teacher 2 spent an average of 7.09 minutes in review. The day-to-day variance in this behavior was also much greater for teacher 2. Second, in the small-group approach, teacher 2 spent less time in controlled practice than did teacher 1, and overall the teachers spent somewhat less time in controlled practice when teaching in the small-group approach than they did when teaching the large-group approach.

Descriptive Statistics on Aptitudes and Outcomes

Table 2 shows the means and standard deviations of the aptitude and outcome scores of students in all classes. Means and standard deviations of the aptitude scores were similar across the four classes. The average score on the preference for learning in small groups scale differed by

Table 1

Mean Number of Minutes Coded Per Day in the Observation Categories

Observation category		Small-group approach		Large-group approach	
		1[a]	2[a]	1[a]	2[a]
		(matched)	(mismatched)	(matched)	(mismatched)
Teacher reviews					
	M	2.06	7.09	4.37	5.60
	SD	2.81	8.43	4.58	3.95
Teacher lectures					
	M	9.65	9.89	10.44	11.90
	SD	4.72	7.08	6.41	5.71
Teacher asks questions					
	M	4.00	3.43	2.85	4.90
	SD	2.84	4.16	3.37	5.20
Controlled practice					
	M	2.24	0.83	3.78	4.43
	SD	1.86	1.00	4.26	2.42
Small group seatwork					
	M	16.87	15.11	0	0
	SD	4.77	7.75	0	0
Individual seatwork					
	M	0	0	13.85	11.68
	SD	0	0	11.00	8.55
Teacher active monitoring of seatwork					
	M	14.26	11.44	13.37	11.22
	SD	5.68	5.72	10.70	8.68

[a]Refers to teacher

Table 2

Means and Standard Deviations of Aptitudes and Outcomes

Variable		Small-group approach		Large-group approach	
		1[a]	2[a]	1[a]	2[a]
		(matched; N = 24)	(mismatched; N = 24)	(matched; N = 23)	(mismatched; N = 22)
STEP-Math Concepts					
	M	24.21	23.75	22.65	23.64
	SD	8.96	10.44	9.93	10.39
Raven's Progressive Matrices					
	M	29.96	31.04	31.57	29.91
	SD	11.96	10.23	7.15	12.04
Attitude toward mathematics pretest					
	M	50.96	54.00	56.48	51.41
	SD	11.56	11.28	10.09	11.64
Anxiety					
	M	35.67	36.75	36.13	37.27
	SD	6.10	6.52	6.23	7.27
Locus of control					
	M	70.18	74.08	73.52	72.86
	SD	7.32	9.66	11.15	6.85
Preference for learning in small groups					
	M	3.88	1.17	.96	3.73
	SD	1.48	1.01	1.02	2.03
Learn best in small groups					
	M	3.38	1.67	1.35	2.91
	SD	1.66	1.86	1.27	2.47
Achievement posttest					
	M	28.04	29.58	28.65	28.59
	SD	6.48	5.63	5.88	5.15
Retention test					
	M	28.92	30.38	29.91	30.00
	SD	6.50	6.18	6.24	4.67
Attitude toward mathematics posttest					
	M	50.38	52.42	53.70	51.14
	SD	9.56	9.10	10.00	9.79
Attitude toward teaching approach					
	M	26.71	26.88	29.83	28.05
	SD	5.41	6.05	4.46	4.27

[a]Refers to teacher

class because students had been stratified on this variable and assigned to classes so that their preference score either matched or mismatched the approach used in that class. Students' scores on the preference for learning in small groups scale were highly correlated with scores on the learned best in small groups scale (r = .77). Furthermore, students' scores on the STEP math concepts test were highly correlated with scores on the Raven's Progressive Matrices Test (r = .51). Not surprisingly, scores on the achievement posttest were highly correlated with scores on the retention test (r = .92).

Principal-Components Analysis of Aptitudes

In order to approximate the factor score for ability used by Webb (Note 1) and Peterson and Janicki (1979), and because students' scores on several aptitudes were highly correlated, we performed a principal-components analysis on the aptitude scales. Varimax rotation was used. Three factors emerged from the analysis. The first factor was a preference for learning in small groups factor. Preference for learning in small groups and the learn best in small groups scale loaded .89 and .85, respectively, on the first factor. The second factor was an ability factor similar to the ability factor in the Webb study and in the Peterson and Janicki study. The STEP math concepts test loaded .66 on this factor, and the Raven's Progressive Matrices Test loaded .77. The third factor was an attitude/locus of control factor with the attitude toward math pretest loading .47 on the factor, and the locus of control scale loading .60 on the factor. This latter factor was similar to the attitude/anxiety toward math factor used in the Peterson and Janicki study.

The two factors corresponding to those used in the Peterson and Janicki study--the ability factor and the attitude/locus of control factor--were used in the regression analyses.

The Effects of Matching Teaching Approach to Students' Preferences

A two x two (match vs. mismatch by large group vs. small group) analysis of variance was performed on students' achievement, retention, and attitude scores to test the effect of matching the teaching approach to students' instructional preference. No significant main effects for matching on preference were found for students' achievement, F (1, 87) = .78, $p > .05$; retention, F (1, 87) = .68, $p > .05$; attitude toward mathematics, F (1, 87) = .08, $p > .05$; or attitude toward teaching approach, F (1, 87) = .79, $p > .05$. The main effect of treatment and the match x treatment interaction were also nonsignificant in all analyses.

The above analyses were performed using all students, but because students were stratified on preference using a median split, many students in the middle of the distribution had the same scores and had to be assigned randomly to one approach or the other. We decided to perform another analysis with only students who had extreme scores on preference for learning in small groups (scores ≤ 1 or scores ≥ 5) and who, therefore, had been truly matched or mismatched to the teaching approach that they preferred. Again, there was no significant effect of matching on students' achievement, F (1, 49) = .84, $p > .05$; retention, F (1, 49) = .43, $p > .05$; attitude toward mathematics, F (1, 49) = .03, $p > .05$; or attitude toward the teaching approach, F (1, 49) = .76, $p > .05$. The main effect of treatment and the match x treatment interaction were also nonsignificant.

Finally, analyses were performed within each teaching approach on selected observation variables to determine if matching on students' preferences affected students' behavior in the approach to which they had been assigned. All students were included in these analyses. Within the small-group approach, students in the matched vs. mismatched class differed significantly in the number of intervals a student spent explaining in the small group during seatwork, t (1, 46) = 2.27, $p < .05$, and the number of intervals during which a student received an explanation in small-group seatwork, t (1, 46) = 1.99, $p < .10$. Analysis of the means in the two classes indicated that out of the 18 20-second intervals during which a student was observed per day, the average student in the matched small-group class spent more time explaining to other students in the small group during seatwork ($\bar{X}$ = 1.17) than did students who were in the mismatched small-group class ($\bar{X}$ = .53). Similarly, students in the matched small-group class were involved in receiving more explanations from other students during small-group seatwork ($\bar{X}$ = .88) than were students in the mismatched small-group class ($\bar{X}$ = .50).

Aptitude-Treatment Interactions (ATI)

Generalized regression analyses were performed on achievement, retention, and attitude scores to test for ATI. As suggested by Cronbach and Snow (1977), deviation scores were used for the aptitudes in the regression analyses, and effect coding (-1 and +1) was used for the treatments. Although Cronbach and Snow (1977) describe a step-up or hierarchical procedure for testing ATI, Cronbach (Note 4) has recommended a simultaneous procedure in which the R^2 and F ratio for a given term are calculated by stepping down from the full regression model to a regression model without

that term in the equation.

Aptitudes, teacher, and treatment were entered into the equation. The aptitudes included the factor score for ability and the factor score for attitude/locus of control. Because teacher was confounded with matching vs. mismatching on preference in this study, the test of the teacher effect was the same as the test of the effect for matching on preference.

The two first-order ATI terms were entered into the equation along with an $(\text{ability})^2$ x treatment term. This latter term was included because Webb (Note 1) found a significant curvilinear ATI for ability. Scores for $(\text{ability})^2$ were made orthogonal to ability using orthogonal polynominals (see, for example, Kendall & Stuart, 1967) so that the regression coefficient for ability would represent the linear effect of ability and would not be changed by the addition of the quadratic term.

A simultaneous procedure, as described above, was used here to test aptitudes, teacher, treatment, and ATI. Each aptitude, teacher, or treatment term was tested by stepping down from a regression model, including aptitudes, teacher, and treatment only, to a model without that term in the equation (see Serlin, Note 5). Each ATI term was tested against the full model.

The numerator of the F ratio was the R^2 due to the variable or group of variables being tested divided by the number of terms being tested. The denominator was 1 minus the proportion of variance predicted by the full model divided by $N - k - 1$ df, where N equals the number of subjects and k equals the number of terms in the full model (see, for example, Kerlinger & Pedhazur, 1973, p. 251).

Achievement and retention. Table 3 presents the results of the regression analyses on achievement scores and retention scores. The full regression equation accounted for 57.9% of the variance in students' scores on the achievement test. Ability accounted for the largest proportion of the variance (55.3%) in achievement scores. Teacher, treatment, and the teacher x treatment interaction were not statistically significant. However, the ATI for $(\text{ability})^2$ was statistically significant.

The results for retention were similar to those for achievement. Again, the only significant effects were for ability and for the curvilinear ATI for ability. This curvilinear ATI for ability was examined by computing the regression equations for achievement and retention within each treatment from the unstandardized regression coefficients. These equations are presented in Table 4. The equations for achievement were then used to graph the relationship between ability and mathematics achievement shown in Figure 1. Because within-treatment coefficients for the retention test were nearly identical to those for the immediate achievement test, the graph of the relationship between ability and scores on the retention test is not shown. The curvilinear ATI for achievement and retention scores on ability may be described as follows: High ability students achieved more and retained more in the small-group approach than they did in the large-group approach. Similarly, low ability students achieved more and retained more in the small-group approach than they did in the large-group approach. For medium ability students, there was little difference in their achievement and retention scores in the two approaches although they tended to do slightly better in the large-group approach than in the small-group approach.

Table 3

Summary of Generalized Regression Analyses on Achievement and Retention Test Scores

Variable in regression	Achievement			Retention		
	df	R^2	F	df	R^2	F
Ability	1	.553	106.49***	1	.504	87.61***
Attitude/locus of control	1	.000	.02	1	.001	.23
$(Ability)^2$	1	.001	.16	1	.000	.01
Teacher	1	.005	.88	1	.004	.67
Treatment	1	.000	.00	1	.001	.20
Model including aptitudes, teacher and treatment	5	.554	21.33***	5	.505	17.57***
Residual	86	.446	--	86	.495	--
Teacher x treatment	1	.003	.52	1	.001	.22
Ability x treatment	1	.003	.56	1	.001	.14
Attitude/locus of control x treatment	1	.000	.01	1	.010	1.75
$(Ability)^2$ x treatment	1	.016	3.12*	1	.017	3.03*
Full model	9	.579	12.52***	9	.534	10.44***
Residual	82	.421	--	82	.466	--

*$p < .10$

**$p < .05$

***$p < .01$

Table 4

Regression Equations Within Each Approach

Dependent variable and teaching approach	Constant	b for ability	b for attitude/ locus of control	b for (ability)^2	b for teacher
Achievement test					
Small-group approach	28.29	5.28	-.28	.55	-.89
Large-group approach	29.68	4.76	-.13	-1.50	-.27
Retention test					
Small-group approach	29.17	5.06	.80	.58	-.71
Large-group approach	31.09	4.90	-1.01	-1.59	-.27
Attitude toward math					
Small-group approach	51.13	-2.23	9.15	1.05	.13
Large-group approach	52.27	-3.27	9.65	-.71	.46
Attitude toward teaching approach					
Small-group approach	26.94	-2.07	-.1[illegible]	-.16	-.07
Large-group approach	27.73	.43	2.65	1.[illegible]5	1.10

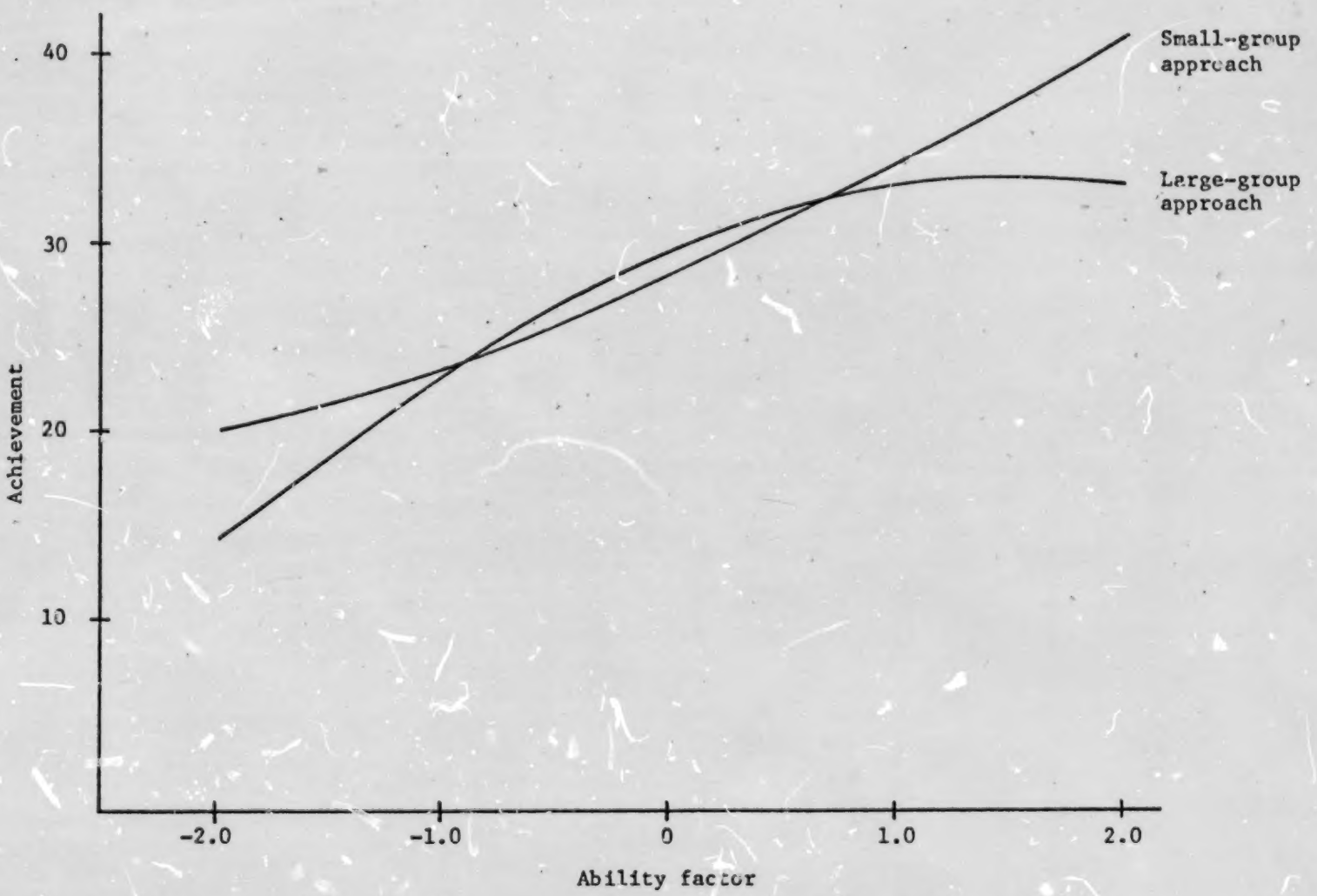

Figure 1. Regression of Achievement on Ability Factor Showing ATI.

Attitude toward mathematics and toward teaching approach. The results of the regression analyses on the attitude posttest are shown in Table 5, and the regression equations are presented in Table 4. The full regression model accounted for 52.6% of the variance in scores on the attitude toward mathematics scale. The majority of the variance accounted for (46.3%) was predicted by the attitude toward mathematics pretest/locus of control factor. Ability was also a significant predictor and accounted for 5.3% of the variance in students' attitude toward mathematics scores. High ability students had less positive attitudes than low ability students. The effects of teacher, treatment, and ATI were not statistically significant.

As shown in Table 5, the full regression model accounted for 18.2% of the variance in students' attitudes toward the teaching approach. A significant treatment effect accounted for 3.7% of the variance. Overall, students had a more positive attitude in the large-group approach. ATIs for ability x treatment and attitude/locus of control x treatment accounted for 4.7% of the variance and 3.0% of the variance in students' attitude toward approach, respectively. The ATI for ability is shown in Figure 2, and the ATI for attitude/locus of control is presented in Figure 3.

The ATI shown in Figure 2 indicates that students above average in ability tended to have a more positive attitude toward the teaching approach in the large-group approach than in the small-group approach. Also, students who were low in ability--whose ability scores were more than one standard deviation below the mean on ability--tended to have slightly more positive attitudes toward the teaching approach in the large-group

Table 5

Summary of Generalized Regression Analyses on Attitude Test Scores

Variable in regression	Attitude toward mathematics			Attitude toward teaching approach		
	df	R^2	F	df	R^2	F
Ability	1	.053	9.64***	1	.019	1.80
Attitude/Locus of control	1	.463	83.51***	1	.021	1.97
$(Ability)^2$	1	.001	.20	1	.000	.01
Teacher	1	.002	.44	1	.001	.66
Treatment	1	.000	.00	1	.037	3.57*
Model including aptitudes, teacher and treatment	5	.518	18.67***	5	.089	1.69
Residual	87	.482	--	87	.912	--
Teacher x treatment	1	.000	.05	1	.012	1.21
Ability x treatment	1	.003	.55	1	.047	4.73**
Attitude/locus of control x treatment	1	.000	.05	1	.030	3.00*
$(Ability)^2$ x treatment	1	.004	.76	1	.016	1.59
Full model	9	.526	10.25***	9	.182	2.06**
Residual	83	.474	--	83	.818	--

*p < .10

**p < .05

***p < .01

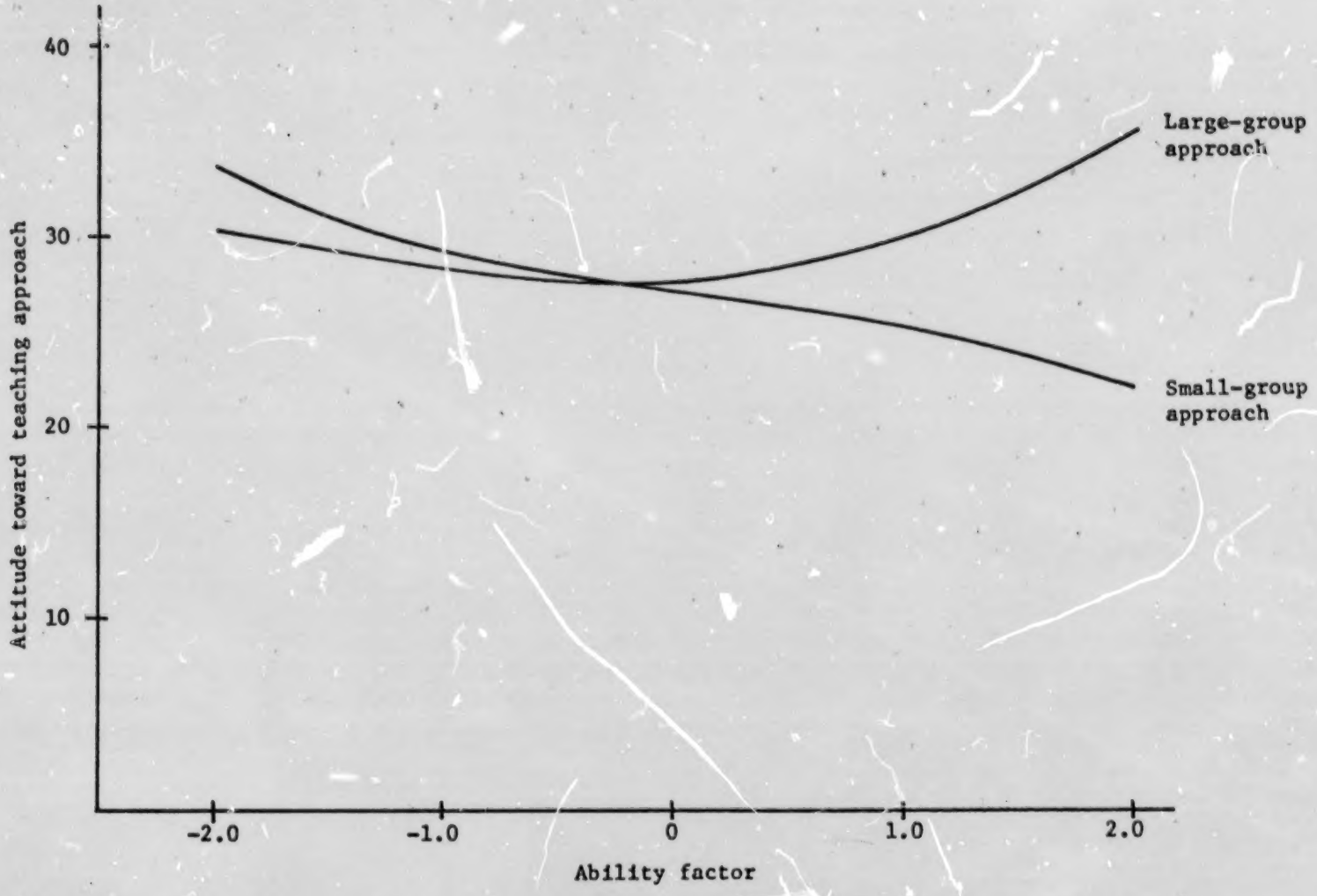

Figure 2. Regression of Attitude Toward Teaching Approach on Ability Factor Showing ATI.

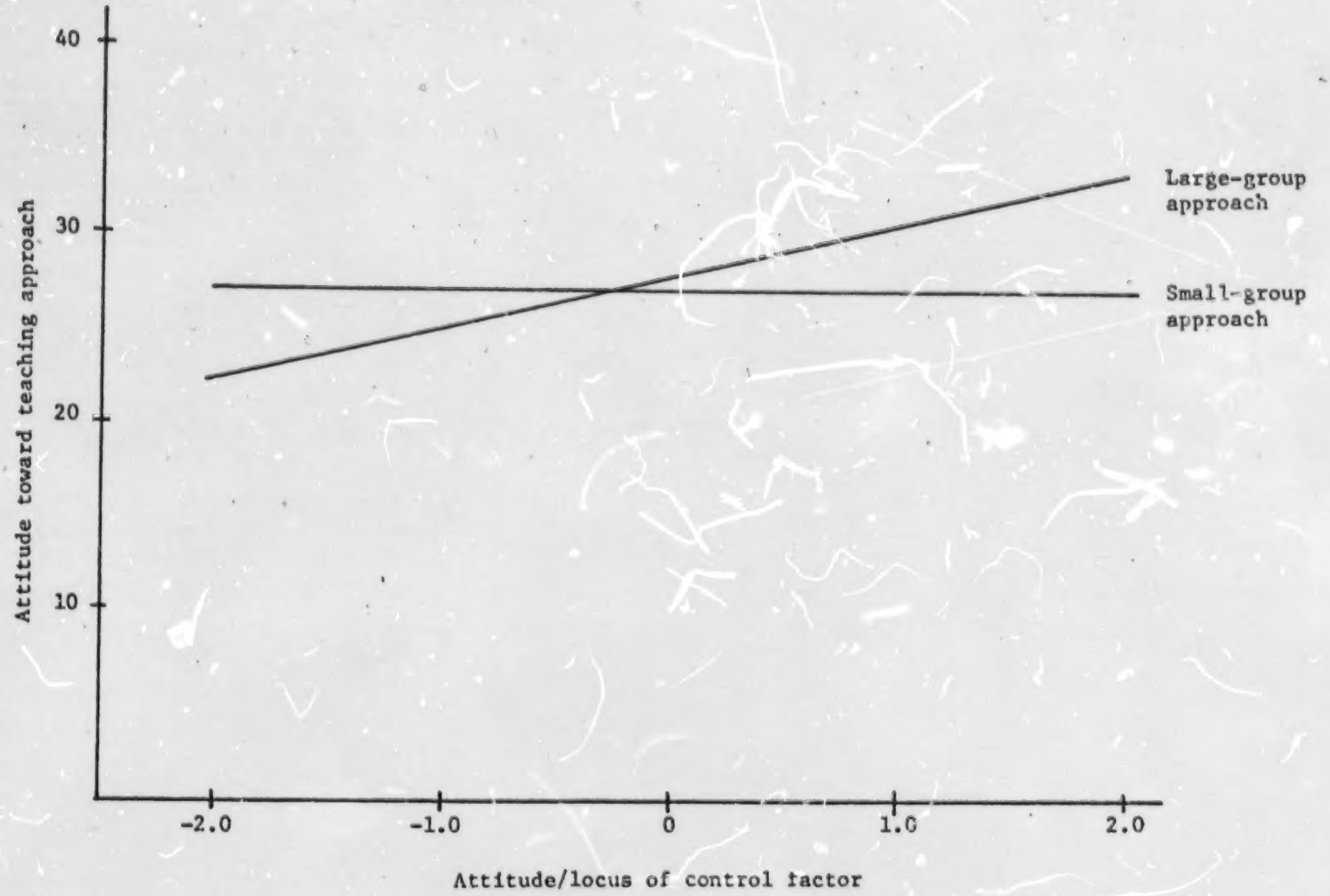

Figure 3. Regression of Attitude/Locus of Control Factor on Attitude Toward Teaching Approach Showing ATI.

approach than in the small-group approach. On the other hand, for students whose ability scores were between the mean and one standard deviation below the mean, there was no difference in attitudes toward the large-group approach and the small-group approach.

The ATI shown in Figure 3 may be described as follows: Students who had high scores on the attitude/locus of control factor--had positive initial attitudes toward mathematics and an internal locus of control--tended to have more positive attitudes toward the large-group approach than the small-group approach. Students who had low scores on the attitude/locus of control factor--had less positive initial attitudes toward mathematics and an external locus of control--tended to have more positive attitudes toward the small-group approach than the large-group approach.

Observations of Group Processes

Webb (Note 1) and Peterson and Janicki (1979) used observations of group processes to explain the processes behind the ATI effects that were found. Similarly, in the present study students' scores on the observation variables were correlated with their scores on aptitudes and outcomes. In particular, correlations with observation variables similar to the group process variables used by Webb and Peterson and Janicki were examined.

Results indicated that within the small-group approach the number of intervals a student spent explaining to or tutoring another student in the small group was positively related to the tutor's scores on the achievement test ($r = .24$, $p < .05$) and the retention test ($r = .27$, $p < .05$) but was unrelated to scores on the attitude toward teaching approach

subscale (r = -.05, p > .05). Furthermore, both ability and $(\text{ability})^2$ were positively related to the number of intervals a student spent explaining to another student. High ability students did more explaining than low ability students (r = .35, p < .01), and high and low ability students did more explaining than medium ability students (r = .24, p < .05). Interestingly, receiving an explanation from another student in the small group was unrelated to the receiver's ability or to the receiver's subsequent scores on the achievement test, retention test, or attitude toward teaching approach posttest.

Two other important variables were the number of intervals a student spent engaged in off-task behavior during seatwork and the number of intervals a student spent waiting for help from the teacher during seatwork. Within the small-group approach, ability was negatively related to students' off-task behavior during seatwork (r = -.24, p < .05), while students' scores on the attitude/locus of control factor were positively related to off-task behavior during seatwork (r = .22, p < .10). Students' off-task behavior was negatively related to their scores on the achievement test (r = -.27, p < .05) and the retention test (r = -.24, p < .05), but were unrelated to students' scores on the attitude toward teaching approach subscale. Within the large-group approach, on the other hand, students' scores on ability and on the attitude/locus of control factor were unrelated to off-task behavior during seatwork. Furthermore, off-task behavior during seatwork was unrelated to students' scores on the achievement test or the retention test, but was positively related to students' scores on the attitude toward teaching approach posttest (r = .31, p < .05).

Finally, the number of intervals that a student spent waiting for help from the teacher during seatwork seemed to be an important variable related to students' attitude toward the teaching approach. Within the small-group approach students who spent more time waiting for help from the teacher tended to have a less positive attitude toward the teaching approach ($r = -.41$, $p < .01$). In addition, students who had a more positive initial attitude toward mathematics and an internal locus of control tended to spend more time waiting for help during seatwork than did students who had less positive initial attitudes toward mathematics and an external locus of control ($r = .25$, $p < .05$). In contrast, within the large-group approach the number of intervals a student spent waiting for help during seatwork was unrelated to students' attitude toward the teaching approach. Furthermore, students' scores on the attitude/locus of control factor were unrelated to the number of intervals students spent waiting for help.

Discussion

The purpose of the present study was to replicate and extend the findings of an aptitude-treatment interaction study by Peterson and Janicki (1979) which was based on a study by Webb (Note 1). Both studies found a significant ATI for ability when students' performance on a delayed test was the outcome. However, Webb found a curvilinear ATI for ability, and Peterson and Janicki found a linear ATI for ability.

To the extent that both the present study and the Webb study found a curvilinear ATI for ability, the results of the present study may be considered to be a replication of the results of the Webb study. However, some differences in the results of the two studies should be noted. First, although in both studies low ability students did better in the small-group approach than in the approach where they learned individually, the findings for high ability students and medium ability students differed somewhat between the present study and the Webb study. Webb found that high ability students did equally well after learning in small groups or individually while the results of the present study suggested that high ability students did better after learning in the small-group approach than after learning individually in the large-group approach. In addition, Webb found that medium ability students did better after learning individually than after learning in small groups, while we found little difference in the performance of medium ability students in the two approaches. Finally, in the Webb study the curvilinear ATI for ability appeared only on the delayed test, while in the present study the

same curvilinear ATI for ability appeared on the achievement test and the delayed or retention test.

A puzzling issue is the apparent nonreplication in this study of the linear ATI for ability found in the Peterson and Janicki (1979) study. This is particularly perplexing in view of the fact that the two studies employed the same treatments and similar aptitude measures with samples of children who were similar in age, socioeconomic status, and type and location of the elementary school that they attended.

This apparent discrepancy between the results of the two studies is resolved when one examines the average and range of ability scores of students in the two studies. The average ability score of students in the Peterson and Janicki (1979) study was considerably higher than that of students in the present study. Students in the present study had an average score on the ability factor of .00 with a standard deviation of .84; students' scores ranged from a minimum of -1.91 to a maximum of 1.84. When students' raw scores on the Raven's and STEP concepts test in the Peterson and Janicki study were used to create ability factor scores identical to those in the present study, it was found that students from the Peterson and Janicki study had an average score on the ability factor of .49 with a standard deviation of .73. Furthermore, these scores ranged from a minimum of -1.58 to a maximum of 1.90. This difference in average ability of the two samples probably resulted from a difference in the way students were selected. In the Peterson and Janicki study, 100 students were selected from the approximately 200 students in the fourth, fifth, and sixth grades in an elementary school. These students were chosen because the teachers identified them as having

the necessary preparation for the fractions unit that was to be taught in the study. In the present study, on the other hand, all the students in the fourth and fifth grades of an elementary school participated in the study. Thus, in the present study students' scores represented the entire range of ability, but in the Peterson and Janicki study students' scores represented only a restricted range of ability.

The implication of this average difference on the ability factor for the ATI results can be seen by considering how the ATI shown in Figure 1 would be changed if the range of scores on the ability factor was restricted as it was in the Peterson and Janicki study. If the lowest ability score were only -1.58, then most of the lower portions of the two curved regression lines would disappear, and the ATI would look much more like a linear ATI than a curvilinear ATI. The "medium ability students" would become "low ability students" or at least students whose scores were below the new mean of .49 on the ability factor. Thus, the only difference between the ATI results for ability in the present study and those in the Peterson and Janicki study is that the results of the present study show what the ATI will look like over the entire range of ability scores. The ATI results of the Peterson and Janicki study showed only what the ATI would look like for the medium and upper part of the range of ability scores with the lowest part of the range omitted. Taken together, the results of the present study, the Peterson and Janicki (1979) study, and the Webb (Note 1) study support the existence of a curvilinear aptitude-treatment interaction for ability when the two treatments involve having students work either individually on problems or together in a small mixed-ability group of students.

The observations of group processes in the present study help explain the ATI for ability and also support the results for group processes reported by Peterson and Janicki (1979) and Webb (Note 1). Results showed that the more time a student spent explaining to or "teaching" another student in the small group, the better was that student's performance on the achievement test and the retention test. However, the number of intervals during which a student received an explanation from another student was unrelated to the receiver's subsequent scores on the achievement and retention tests. High ability students did more explaining than low ability students, and high and low ability students did more explaining than medium ability students. The picture that emerges is that children improved their own learning by teaching other students and that this teaching benefited the child who was the "teacher" more than the child who was the "student." This finding is similar to findings of tutoring studies which have shown that tutoring benefits the tutor more than the tutee (see, for example, Allen & Feldman, 1973; Cloward, 1976). In this study high and low ability students did more explaining than medium ability students and thus, benefited from the small-group approach. Medium ability students, on the other hand, tended not to be involved in explaining to other students in their small group. Thus, medium ability students tended to work individually in the small-group approach as well as in the large-group approach and did equally well in both approaches.

Correlations between off-task behavior, ability, achievement, and retention add some additional information to explain the processes behind the ATI for ability. Within the large-group approach students' scores on ability were unrelated to their off-task behavior, and off-task

behavior was unrelated to scores on achievement or retention. Within the small-group approach, on the other hand, high ability students tended to be off-task less than low ability students, and off-task behavior was negatively related to students' scores on the achievement test and the retention test. These data suggest that high ability students did well in the small-group approach because they tended to stay on-task. Furthermore, high ability students were probably on-task most of the time because they were the ones who were teaching and explaining to other members of their small group.

Although high ability students tended to have higher scores on the achievement test and the retention test in the small-group approach than in the large-group approach, they tended to have less positive attitudes toward the teaching approach in the small-group approach than they did in the large-group approach. This is not surprising in view of the fact that high ability students appear to have been working much harder in the small-group approach than they were in the large-group approach. In the large-group approach high ability students were doing their own work, but in the small-group approach, high ability students were helping other students as well as doing their own work. It is not surprising, therefore, that students would dislike the approach in which they had to work the hardest (see, for example, Peterson, 1977). One should note that this dislike did not extend to students' attitude toward the subject matter. High ability students had equally positive attitudes toward mathematics in the small-group approach and in the large-group approach.

A second ATI finding for attitude toward the teaching approach indicated that students who were high on the attitude/locus of control factor--

had more positive initial attitudes toward mathematics and an internal locus of control--had more positive attitudes toward the teaching approach in the large-group approach than in the small-group approach. Students who were low on the attitude/locus of control factor--had less positive initial attitudes toward mathematics and an external locus of control--had more positive attitudes toward the teaching approach in the small-group approach than in the large-group approach.

Again, the observation data provided some insight into the possible psychological processes mediating the relationship between attitude/locus of control and attitude toward teaching approach in the two treatments. An important variable seemed to be the amount of time a student spent waiting for help in the two approaches. In the small-group approach, students who were high on the attitude/locus of control factor tended to spend more time waiting for help from the teacher during seatwork than did students who were low on the attitude/locus of control factor, and students who spent more time waiting for help during seatwork tended to have less positive attitudes toward the teaching approach. In contrast, in the large-group approach, students' scores on the attitude/locus of control factor were unrelated to the number of intervals a student spent waiting for help, and the number of intervals a student spent waiting for help was unrelated to students' attitude toward the teaching approach. These observations suggest that for some reason the students who had positive initial attitudes toward mathematics and an internal locus of control spent more time waiting for help in the small-group approach than did students who had less positive attitudes and an external locus of control. These students may have become impatient and began to dislike

the small-group approach as a result.

Another important finding of this study is the lack of a significant main effect for treatment on achievement and retention scores. Peterson & Janicki (1979) found no significant main effect of treatment on the achievement test or the retention test, although a significant treatment effect appeared for students' attitude toward the teaching approach with students having a more positive attitude toward the approach in the large-group approach than in the small-group approach. Similarly, we found that on the average, students did equally well on the achievement and the retention tests in the large-group approach as in the small-group approach. These results contradict proponents of direct instruction such as Rosenshine (1979) who have argued that students learn more when working in large-group settings than in small-group settings. In support of the Peterson and Janicki (1979) findings, we did find a significant treatment effect for students' attitude toward the teaching approach. Students, on the average, tended to have a more positive attitude toward the teaching approach in the large-group approach than they did in the small-group approach.

Finally, the results of this study neither confirm nor refute the utility of matching the teaching approach to the students' own preference. In the present study students' initial preferences were used to either match or mismatch them to a teaching approach. Results indicated that matching on students' preferences did not significantly affect their achievement, retention, or attitudes. Interestingly though, matching on students' preferences did appear to affect the amount of interaction that occurred within the small groups in the small-group approach. Students

in the matched small-group class spent more time interacting in their small groups than did students in the mismatched class. Students in the matched small-group class both gave and received more explanations than did students in the mismatched small-group class. Perhaps those students who had initially expressed a preference for the small-group approach were those students who felt most comfortable interacting with other students and thus, were more likely to interact with other students when actually placed in the small-group approach. The mismatched students, on the other hand, were students who had expressed a preference for the large-group approach and thus, were probably less comfortable working with other students than they would have been working alone. They may have been more shy and reticent in their interactions with others in their small group.

A major limitation of the present study is that the match vs. mismatch comparison was confounded with the effect of teacher. Thus, we cannot determine from the present study whether the lack of significant findings for achievement and retention was due to the lack of a significant effect for matching on preference or to the lack of a significant effect for teacher or to both. For example, a significant effect in favor of matching on preference may have been cancelled out if the particular teacher who taught the matched classes happened to be the less effective teacher. Further research with more classes and more teachers is needed to determine the effects of matching and mismatching the teaching approach to students' preferences.

In conclusion, the ATI findings for ability support those of Webb (Note 1) and Peterson and Janicki (1979). Although the present findings

do not constitute an exact replication of previous results, they do suggest a replicable ATI pattern in the form of a curvilinear ATI for ability when the treatments require a student either to work alone or to work in a small mixed-ability group. Furthermore, the results of the three studies demonstrate that the important psychological processes mediating this ATI finding appear to be those involved when students teach other students. These findings are important because they suggest that consistent ATI findings can be accumulated across several studies. In contrast to the pessimistic conclusions of other researchers who have suggested that ATIs cannot be replicated (see, for example, Cronbach, 1975; Walberg, 1977; Tobias, Note 6) the present findings strike a note of optimism for ATI researchers.

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